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Access Control, Safety Signs, and Alarm Systems

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Definitions

Access control system	An assembly of equipment and administrative procedures to control the access of personnel to a hazardous area. Components that may be included in an access control system are signs, lights, barriers, interlocks, and run/safe boxes.
Alarm system	A warning system to alert personnel to the presence of an unexpected hazard or degradation in safe working environment, usually requiring immediate action. Also see "warning system" below.
Area access control light panel	An LLNL term applied to all variations of powered visual annunciator panels used at the entrances to hazardous areas to control personnel access.
Barricade	A temporary structure set up across a route of access to deter passage of persons or vehicles.
Barrier	A permanent physical device to protect personnel from a hazard by controlling access to the area where the hazard exists (e.g., fences and machine guards).
Beacon	A flashing or rotating light. Because of their nonspecific, wide area of coverage, beacons are primarily intended for use inside hazardous areas rather than outside.
Immediate evacuation alarm	A rapidly pulsing high-pitched tone that has replaced the Klaxon horn as the LLNL standard immediate evacuation alarm.
Interlock	A device to prevent an action from occurring when injury or property damage may result. Interlocks are classified into three main types: key-operated, mechanical, and electrical. A specific interlock, however, may involve more than one of the above types.
Interlock bypass	A means by which the function of an interlock is defeated.
Key-interlock	An interlock in which a key is used to enable or disable the interlocked function, through electrical or mechanical means, or both.
Lock-controlled master switch	A key-operated interlock installed at the main control console for operating hazard-producing equipment.
Push-to-safe switch	A switch that must be installed inside of exclusion areas, such as an accelerator, to enable a person trapped inside to prevent or terminate operation of the hazard-producing equipment.
Run/safe box	An interlock system component that houses a push-to-safe button and a sweep-interlock switch.
Single-point failure	Denotes the loss of function or safety as a result of a single, credible event.

Sweep interlock	A complete tour of a hazardous area required in order to manually activate the run/safe boxes or status control units before operating the hazard-producing equipment.
Status control unit	An improved version of the run/safe box; includes a status indicator, as well as a push-to-safe button and a sweep-interlock switch.

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Access Control, Safety Signs, and Alarm Systems

11.01 Introduction

This chapter provides guidance for the design, selection, and operation of personnel access control and alarm systems, including such elements as signs, lights, audible warning devices, and barricades and barriers. Access control systems function by controlling the access of personnel to potentially hazardous areas, and alarm systems function by providing warning of any potential or actual degradation in the safety of an area or operation. Obtaining, installing, and maintaining these systems is a programmatic responsibility. Health & Safety Manual *Supplement 11.07* discusses personnel safety interlocks, including lock-controlled master switches, run / safe boxes, and status control units.

11.02 General Design, Installation, and Operating Requirements

All exterior and interior alarm systems must meet the requirements of DOE Order 6430.1A sections 1670 and 1671.

Fail-Safe Response

Hazard-producing equipment must be designed to prevent single-point failures from endangering personnel, particularly at the primary means of removing the hazard, such as at a single circuit breaker. Use multiple paths or methods to avoid common-mode failures in circuits, etc.

Tamper Resistance

Design access control and alarm systems to minimize the potential for unauthorized or inadvertent changes to safety equipment and wiring. Lock interlock enclosures; run wiring in conduit or otherwise acceptable tamper-resistant wire ways; use screw covers or lockable enclosures.

Training and Qualification of Personnel

Personnel who operate or maintain hazard-producing equipment must be trained and formally qualified to operate or maintain the hardware in a safe manner. A list of personnel so qualified, including the person who is principally responsible for the equipment or area, should be posted near the entrance to the equipment or area concerned.

11.03 Selection of Access Control Systems

Table 11-1 presents a summary of required access controls based on the severity of the hazard or hazards that may be present in an area.

Selection of access control systems for radiological areas must be in accordance with the requirements of DOE Order 5480.11, section 9.L (also see Section 33.12 of this *Manual*).

Use low voltage (50 V ac / dc or less) if possible to avoid creating secondary hazards.

11.04 Signs

Any area where a hazard exists must be identified with a safety sign to alert employees to the hazard and inform them of the required actions. Other access controls may be installed as additional safeguards. To ensure uniform response by personnel, all safety must be of the same type for similar hazards. The format for traffic signs must follow the requirements of the Uniform Traffic Control Devices Code. Signs on poles should be mounted a minimum of 7 ft above ground level.

Safety signs for controlled and radiological areas must meet the requirements of DOE Order 5480.11, section 9.K.

Safety Sign Format

Each safety sign must have the appropriate color and include the following:

- An approved heading that indicates the degree of hazard.
- Statement of the type of hazard.
- Statement of what action to take.

See Fig. 11-1 for examples of signs.

Figure 11-1. Examples of safety signs.

Types of Signs

Danger Signs. Use these signs only in areas where a significant, immediate hazard exists that could produce serious injury or death. The heading "Danger" is printed in white letters on a red oval edged with a rectangular black border. The body of the sign is white, and the message is in black.

Caution Signs. Use these signs in areas where injury is possible and personnel must be on their guard. The heading "Caution" is printed in yellow letters on a black rectangle. The body of the sign is yellow, and the message is in black.

Notice Signs. Use these signs for providing information. The heading "Notice" is in white letters on a green rectangle when the message relates to safety and on a blue rectangle for other messages. The body of the sign is white, and the message is in black.

Direction Signs. Use these signs to indicate exits, fire escapes, evacuation routes, stairways, first aid, etc. The direction symbol appears near the top in white on a green rectangle. The body of the sign must have a color that contrasts with the general background.

Radiation Signs. For radiation hazards, use standard Danger or Caution signs that also prominently display the radiation symbol, a three-bladed black propeller on a yellow background. Use the Danger signs only in areas where there is a risk of immediate injury or death. Such areas could contain accelerator beam cells; exposed, large radioactive sources; and unshielded x-ray machines. Use Caution signs to designate areas where the risk is limited to receiving unnecessary radiation doses or receiving radiation doses that could exceed the DOE dose limits, but where clinically detectable injury would be unlikely.

Areas where radioactive materials are handled or where radiation-producing equipment is used shall be posted in accordance with the provisions of DOE Order 5480.11. The basic requirements are as follows:

- *Access Control.* The access to any area where radioactive materials or elevated radiation fields may be present shall be clearly and conspicuously posted as an access-control area.
- *Radiological Area.*

—Posting for External Radiation. The access to any area where radioactive materials or elevated radiation fields are present above certain prescribed limits during normal operations shall be posted according to the following requirements:

"Radiation Area" for any area within an access control where an individual can receive a dose equivalent greater than 5 mrem but less than 100 mrem in 1 hr at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates.

"High Radiation Area" for any area within an access control where an individual can receive a dose equivalent of 100 mrem or greater but less than 5 rem in 1 hr at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates.

"Very High Radiation Area" for any area within an access-control area where an individual can receive a dose of 5 rem or greater in 1 hr at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates.

—Airborne Radioactive Material Area. The access to any area where airborne radioactive material concentrations are greater than 1 / 10 of the DACs given in DOE Order 5480.11, Attachment 1, shall be clearly and conspicuously posted.

—Surface Contamination Area. The access to any area where surface contamination levels greater than those specified in Table 33-3 of Chapter 33 of this *Manual* are present shall be clearly and conspicuously posted.

—High Surface Contamination Area. The access to any area where surface contamination levels are greater than 100 times those specified in Table 33-3 are present shall be clearly and conspicuously posted.

Obtaining Signs

Consult Hazards Control regarding the type of sign needed and its source of supply. Central Supply maintains a stock of signs that are used frequently; Hazards Control stocks some signs that are in low demand. Special signs may be custom-made in the Shops or purchased outside with the requestor's funds. It is important that any custom-made signs conform to the criteria previously stated for each category and that all signs have rounded corners.

11.05 Lights and Audible or Visual Warning Devices

Warning lights or audible warning devices are required in Class B, C, and D hazard areas (see Table 11-1) where they are needed to warn personnel against remaining in or entering a hazardous area. Building personnel must be instructed on the meaning of and the action required when an alarm sounds. An explanatory sign must be posted immediately adjacent to a warning device to specifically describe the hazardous condition and indicate what course of action must be taken. In a highly illuminated area, it may be necessary to surround a light with a disk or wide-angled cone of a contrasting color to make the light more visible. The criteria discussed in this section apply only to warning devices used for safety purposes and do not include lights used at control consoles to indicate equipment status. For danger (red) or caution (yellow) warning lights, the following must be adhered to:

- The warning light and accompanying sign identifying the hazard must be on the final barrier that

Table 11-2. Accepted used of audible and visual warning devices.

Warning Device	General Use	Personnel Action
Red light	**Danger**	**Do not enter**
Magenta or safety purple light (with or without chimes)	**Danger—High radiation area**	**Do not enter**
Yellow light	**Caution**	**Limit free access of personnel and warn them to be on alert**
Green light	**Area open**	**No entry restrictions**
Blue (or white) light	**Notice**	**Condition requires monitoring action by responsible operating personnel**
Immediate evacuation alarm, wavering tone	**Danger—Criticality accident or imminent high radiation exposure, toxic material release, large fire, etc.**	**Evacuate—Leave building or area immediately**
Air horn, steady	**Danger—Fire in HE area**	**Take cover immediately; do not approach**
Chime, pulsed	**Danger—High radiation area (usually used with magenta light)**	**Do not enter**
Other sounds (bells, buzzers, etc.)	**Warning—Hazardous condition exists**	**Be on alert; follow directions**

Note: The lights listed are to be of the flashing, rotating, or oscillating type.

an employee would encounter when approaching a hazard.

- The warning light must reflect the status of equipment or hazardous condition inside of the barrier.
- Employees are not permitted access beyond a red warning light for routine operations. For specific, short-term activities, when access is an absolute necessity, a Safety Procedure (SP) must be written and approved by the department head or division leader. The SP must describe planned activities in detail and designate individuals authorized to work beyond the danger warning light or sign. When specific tasks or operations are approved by an SP, a minimum of two authorized individuals must be present when work is being performed. (See Section 23.06 of this *Manual*). Responsibility for access by transient personnel or visitors must be assumed by the experimenter responsible for the area.
- All warning lights installed to warn of a hazardous situation must be of the flashing, rotating, or oscillating type.
- Generally, beacons are to be avoided as warning lights. Care should be taken to "size" the warning light to illuminate only the area of the hazard.
- Table 11-2 lists various audible and visual warning devices, their meanings and use, and the required personnel action.

11.06 Barricades and Barriers

The effectiveness of audible and visual warning devices is strongly influenced by many human factors (e.g., fatigue and distraction). To compensate for this, the use of physical barriers in conjunction with the signs and warning devices must be considered. If the hazard is great enough (see Table 11-1), additional audible and visual warning devices, such as lights and alarms, may also be required. Their function is to warn personnel of their approach to a final barrier, behind which a hazard exists. When choosing the type of barrier for your needs, consider the following:

- The nature of the hazard.
- The need for the barrier to be well constructed and durable and not interfere with the operation of your equipment or experiment.
- The circumstances under which it can be opened or removed.
- The need for the barrier not to create new hazards.
- The need for the barrier to prevent missile or fragment penetration and eliminate harmful overpressures associated with some hazards.
- The need for the barrier to serve as a shield to reduce radiation in occupied areas to acceptable levels.

In some cases, design engineers or experimenters must prepare a Safety Note (see Section 6.21 of this *Manual*) to ensure proper design, fabrication, assembly, installation, and testing of these barriers.

Open-Trench Barricades

Groups engaged in construction and maintenance work requiring open trenches or excavations must provide protection for pedestrians, bicyclists, and vehicular traffic. Where possible, backfill immediately or provide a continuous covering. If this is not possible, provide barricades to warn personnel of the presence of the trench and its danger. Construction personnel must be aware of normal traffic patterns and emergency evacuation routes, and must provide walkways adjacent to occupied buildings, main thoroughfares, intersections, and at recognized pedestrian traffic locations.

A construction barricade must meet the following criteria:

- Type II barricades, as defined in ANSI Standard D-6.1, must be positioned at 10-ft (3-m) intervals on each side of the trench. When viewed from the side, barriers on opposite sides of the trench should not appear to be adjacent to each other but offset at 5-ft (1.5-m) intervals.
- Each barricade should be placed at least 2 ft (0.6 m) away from the opening.
- Each barricade that will remain in place during periods of darkness must be equipped with a 20-cm-diameter yellow flasher visible to oncoming vehicular and pedestrian traffic.
- When continuous solid barriers, such as fences, are not provided, tie interconnecting ropes or special yellow plastic strips (available from Stores, stock no. 4280-65028) between the barricades. If ropes are used, attach streamers between the barricades.
- Crossing points must be identified in construction drawings and sketches so that walkways and bridges with standard guard rails (or equivalent) can be provided. Furnish adequate lighting at the crossing points.
- Wherever vehicular traffic crosses a trench, install metal-plate coverings for weight support.

Fences

A fence that is at least 4 ft (1.25 m) high can be used as a barrier. A barbed-wire top extension should be added to a chain link fence if warranted by the hazard. Provide at least one vehicle gate at least 12 ft (3.7 m) wide for each enclosure to permit entry of emergency apparatus.

Electrical Equipment Enclosures

For design and fabrication details, see Section 23.32 of this *Manual*.

Locks

All doors, gates, or removable panels that permit entry through a barrier into an enclosure must be locked, or equipped with interlocks, or both depending on the hazard. A variety of locks and padlocks are available from Central Supply. The Security Department has a lock specialist who can be contacted for assistance.

Machine Guarding

Unguarded machinery and machine tools are the cause of many severe and disabling injuries. To prevent these injuries, LLNL requires the installation of guards on all hazardous moving parts of machines. Machine guards must be securely attached to the equipment in such a way that it requires a tool to remove them. Examples of hazardous moving parts include V belts, gears, rotating saw blades, and abrasive wheels. The Industrial Safety Group (ext. 2-1322) is responsible for advising supervisors on guarding requirements and guarding methods. Information on guarding can also be found in the OSHA General Industry Standards and many ANSI safety standards.

Guarding hazardous parts of machinery significantly reduces the risk of injury to the operator. In addition, the following safe-work practices should always be followed when operating machinery or machine tools.

- Guards shall not be removed unless specifically authorized by the supervisor.
- If guards are removed for repair or maintenance of machinery, all power supplies must be secured and mechanical energy sources blocked.
- Missing or defective guards must be reported to the supervisor immediately.
- Operators must avoid loose clothing and confine long hair to prevent its becoming entangled in machine parts, such as rotating spindles and gears.
- Appropriate eye protection must be worn while operating machinery or machine tools.

Entry Through Safety Barriers

Barriers are installed to prevent interaction of hazards and people. Signs must be posted to inform persons of the hazards involved and any special pre-

cautions to be observed. Personnel should pass through a barrier into an enclosure only at designated entry points and in the manner prescribed by posted instructions. Doors, gates, removable panels, and other places where entry is permitted should be locked or interlocked to prevent unauthorized entry.

Where padlocks are used on entry points and duplicate keys are available, care must be exercised to prevent a person with a second key from being in the controlled area without the knowledge of the first person. Where a lock-controlled master switch is installed in the interlock circuitry, the person entering through the barrier must retain possession of the solitary key and upon leaving verify that no one is locked inside. This key shall be the only key that can open the doors or gates into the enclosed area.

Securing Areas Controlled by Safety Barriers

Operators of equipment protected by a barrier must inspect all regions within the enclosed area in an orderly manner (i.e., conduct a safety sweep) and give warning to ensure that no employees remain inside when the area interlocks and run/safe box chains are made up, the barrier is secured, and the equipment is reactivated.

11.07 Interlock Systems

Personnel Safety Interlock Circuits must be checked for proper operation after installation or after any modification, and quarterly thereafter unless otherwise specified. (See Section 33.48 of this *Manual* for accelerator interlock check requirements and Section 33.47 for x-ray machine interlock check requirements.) Conditions found during the check should then be noted in the equipment log or other record. Keys must be controlled to prevent unauthorized personnel from gaining access to or operating equipment. If a lock-controlled master switch is used in the interlock chain, the key that controls the locks shall be the same key used to gain access to the equipment. A status panel shall be used to continually monitor the interlock circuits. For specific information on the design and installation of Personnel Safety Interlock systems, see Health & Safety Manual *Supplement 11.07.*

Means for Bypassing an Interlock

For momentary (15-sec) bypass of laser safety interlocks, see Section 28.09 of this Manual.

All other entry interlocks may be bypassed or rendered inoperative only under strictly controlled conditions that have been approved by management through an OSP. During the period of bypass, the status of the equipment must be posted in a conspicuous place. When the bypassed interlock is no longer needed, the interlock must be promptly reactivated.

Operators of equipment protected by an interlock must inspect or give a warning to ensure that no employees are in the enclosed area when the equipment is reactivated.

Interlocks are for personnel safety and must never be relied on as the main means of disconnecting equipment power. A lock-and-tag procedure for this purpose is described in *Health & Safety Manual*, Supplement 26.13.

11.08 Alarm Systems

In the event that there is a potential or actual degradation in the safe working environment in a facility, personnel in the area should be alerted by a warning system so that they can take appropriate action. These alarm systems may respond, for example, to an increase in the radiation exposure rate, to the presence of a combustible gas, or to the presence of smoke. In this *Manual*, fixed installation systems that alert workers or the Fire Department to a change in the safe environment are defined as "alarm systems." Examples of typical alarm systems are: a constant air monitoring system for radioactivity, a criticality alarm system, or a fire alarm system.

The alarm system may also be designed to initiate some action such as shutting off the high voltage to an accelerator or x-ray machine, closing a fire barrier door, or alerting the Fire Department. The degree of sophistication and reliability of the alarm system should be commensurate with the potential hazard involved.

Evacuation Alarm Systems

All on-site buildings and each dangerous operation area indoors and outdoors must be equipped with devices for notifying personnel to leave the area. The general alarm is the continuous sounding of the LLNL standard "immediate evacuation" alarm (wavering sound), which must be used only to warn employees to evacuate the building immediately. Another method is to use the building emergency PA system. In either case, personnel should immediately go to the prearranged assembly point or as otherwise directed.

The extensiveness and reliability of the alarm system must be proportional to the magnitude of the credible accidents that could occur from operations in or near the building. The facility supervisor and Hazards Control will jointly decide the type of evacuation alarm system that is needed (see Table 11-2). Specific guidance on immediate evacuation alarms for use in installations where ionizing radiation exposures might occur is contained in ANSI/ANS N2.3.

11.09 Management Review and Documentation Requirements

Design Reviews

The designs, including software, of all systems and modifications to systems that perform a safety function or that control a potentially hazardous operation shall be reviewed and approved at the level of the project engineer or group leader or above.

Documentation

System drawings, specifications, and Laboratory Engineering Notes (LENs) will be prepared and maintained according to the standards of the Electronics Engineering Department, Mechanical Engineering Department, or the Plant Engineering Department, whichever organization is principally responsible for the system and area concerned.

Software

System control software will be reviewed and documented according to a formal quality assurance procedure.

11.10 Reliability, Testing, and Maintenance Requirements

Reliability

Because of their importance to safety, the reliability of access control and alarms systems must be high. Reliability requirements for a specific system must be developed by the responsible planners and designers as part of the risk assessment process described in Chapter 2 of this *Manual*, preferably before detailed design and hardware selection begins.

Testing

Performance verification tests must be performed when a system is installed or modified, and at least quarterly thereafter. Testing should be conducted more often if it is needed to assure that reliability requirements are met.

Required tests must be conducted according to written test procedures, and reviewed and cosigned at the level of project engineer or group leader or above.

Inspections and Preventive Maintenance

Preventive maintenance and inspections should be performed on a regular basis, preferably according to a published schedule.

11.11 Software-Driven and Solid-State Devices

Programmable controllers are frequently used for personnel protective systems in many Laboratory facilities. The following list will provide guidance to aid in equipment selection, integration, and operation:

- The equipment itself should be well characterized by use in other than personnel protective systems so that reliability, maintainability, and operability is known.
- Continued operation in the event of system or component failure is necessary for safety reasons, then redundant systems should be selected.
- Hard-wired feedback loops should be included to indicate any irregularities in the system.
- The activation of any safety sensor or the failure of critical systems or components should cause a "fail-safe" condition to be instituted, with safety of personnel and protection of equipment as the end result.
- Software system instructions should be incapable of permanent modifications without proper authority. This can be by means of a key-lock, coded instruction, or similar control.
- Temporary modifications ("soft-buggers") to the personnel warning and interlock system should be cancelled when the system is placed in a startup or power-available mode.

11.12 Access Control in Security Areas

DOE Order 6430.1A, section 0110-13.2.1, requires that when a potentially hazardous area is also a security area the following criteria must be met:

- A minimum number of entrances shall be provided for security areas. However, exits from security areas shall be adequate to satisfy the requirements of NFPA 101. Some exits may be provided for emergency use only.
- Entrances to and exits from security areas shall be equipped with doors, gates, rails, or other movable barriers that will direct and control the movement of personnel or vehicles through designated portals.
- Panic locks used on emergency exit doors in security area perimeters shall be operable only from the inside and shall be equipped with at least a loud local alarm. Door locks and latches shall comply with NFPA 101.
- All nonmonitored exits from protected areas, material access areas, or vital areas shall be equipped with intrusion alarms.